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THE DEPARTMENT OF DEFENSE

STATEMENT ON

THE SCIENCE AND TECHNOLOGY PROGRAM

BY

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DEPUTY DIRECTOR DEFENSE RESEARCH AND ENGINEERING

(RESEARCH AND ADVANCED TECHNOLOGY)

TO

SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT
OF THE
COMMITTEE ON ARMED SERVICES
UNITED STATES HOUSE OF REPRESENTATIVES
101ST CONGRESS, FIRST SESSION

MARCH 23, 1989

Mr. Chairman and members of the Committee:

I. INTRODUCTION

I am pleased to testify in support of the Defense Science and Technology (S&T) program for FY 1990 and FY 1991.

A strong national security posture is a combination of national resolve, industrial capability, morale, leadership, training and other ingredients. In addition, there is a pervasive need for superior equipment that can provide an edge over a range of combat situations. Fundamental to acquiring this equipment is the availability of technical options responsive to combat needs that can be the basis for developing increasingly effective systems. It is the task of the S&T program to provide the technical options that will enable the deterrence of future aggression and preclude adverse technological surprise.

A significant advantage the United States enjoys over potential adversaries is the existence of a broad, high-quality and innovative private sector, which also is a principal performer of the Department of Defense (DoD) S&T program. This is particularly important because industry is the ultimate producer of our equipment, and transfer from laboratories to production lines is facilitated when the developers of the technology are also the producers of its products.

Manufacturing technology and other industrial-base programs complement our S&T program by ensuring an efficient and effective transition from a new idea to a military product. In addition, our major allies have strong and innovative technology bases that further enhance our national security posture. However, a

technology lead is a perishable commodity, and the challenge is to maintain our lead and search for new approaches to create a more competitive edge.

As indicated earlier, the combat capability of our armed forces is determined by factors other than just the number of tanks, ships, planes and other weapons in the inventory. Our strength depends upon what our weapons can do: their accuracy, speed, firepower, reliability, etc. The Bradley fighting vehicle is much more capable than the armored personnel carrier it replaced. The Aegis antiair warfare system provides a dramatic increase in firepower and coverage when compared to older ships being retired. In addition, the new LANTIRN navigation system will enable our tactical aircraft to operate effectively at night and during reduced visibility. The technological progress we have achieved in these systems can spell the difference between success and failure in the battle arenas of the future.

The technology basis for these advanced systems was laid in the 1960s and 1970s. It was the forethought, planning and allocation of resources to a technological future in those times that has made possible advanced systems for use today. High quality people paired with superior weapons comprise the best formula for US security today and in the future. Therefore, it is imperative that we provide for that future now by pursuing a strong and innovative S&T program so that today's equipment can be replaced with increasingly more capable weapon systems that will be needed by us and future generations to ensure our national well being and sovereignty.

DoD S&T projects and programs range from fundamental investigations to the search for new techniques to proof-of-concept demonstrations for reducing technical risk and developing a sound basis for entering full-scale development. In budget

terms, the S&T program is made up of budget categories Research (6.1), Exploratory Development (6.2) and Advanced Technology Development (Budget Activity No. 2).

The Research (6.1) program provides the long-term foundation for technological progress. It is from this work that new ideas, innovative concepts, educational progress and technological leadership emerge. The US no longer enjoys an overwhelming research leadership position, and it is important that our universities and other institutions have the resources and facilities required for the country to march forward with technological confidence, both from military and economic viewpoints. For these reasons we afford special management emphasis to the DoD Research program.

The purpose of the Exploratory Development (6.2) program is to facilitate the translation of research results into military applications. For example, solid state electronics research provided the new phenomena that led to integrated circuits but more was required to satisfy a military need. The subsequent electronics developments resulting from those discoveries gave us the ability to sense, locate, acquire, track, identify and destroy targets. These were important contributions that emerged from the Exploratory Development program. In a similar manner, lasers, explosives, combustion, optics, medicine and fluid dynamics are typical disciplines that have provided the basis for laboratory personnel to develop effective techniques in kinetic energy weapons, munitions, aircraft, chemical defense and other essential military materiel. Collectively, these laboratory-developed techniques form the building blocks for future superior equipment.

The Advanced Technology Developments (ATDs) are the bridges that decrease the time to transition laboratory discoveries to

our forces in the field. They are one-of-a-kind demonstrations of systems, subsystems, components, etc., to determine military feasibility and utility. They are selected from promising candidates based on the probability of application to an existing or perceived need and the probability of success toward meeting that need. The ATDs provide a sound cost-effective means for demonstrating, against technological and operational criteria, the materiel that will make up future systems. Because the ATDs are carried out in realistic environments in the early phases of the development cycle they are of great value, at a relatively low cost, in providing realistic cost and technical risk estimates. We consider the ATD portion of the S&T program to be a sound investment.

In summary, our national strategy is based on continued reliance on a technology edge over potential adversaries. It is the most viable option we have and we must continue investment in the S&T program if we are to be successful in maintaining a dominant position in the increasingly sophisticated combat environments of tomorrow.

The current S&T program request for FY 1990 is $5,569 million and for FY 1991 it is $5,845 million. This total does not include the Strategic Defense Initiative amounts that are in the Advanced Technology Development category but covered in separate testimony. Table I outlines details of the request.

TABLE I

FY 1990-91 SCIENCE AND TECHNOLOGY PROGRAM

(Dollars in millions)

	FY1989	FY1990	FY1991
RESEARCH			
Military Departments	725	818	850
Defense Agencies	231	112	113
Total Research	956	930	963
EXPLORATORY DEVELOPMENT			
Military Departments	1,565	1,572	1,614
Defense Agencies	957	791	837
Total Exploratory Development	2,522	2,363	2,451
ADVANCED TECHNOLOGY DEVELOPMENT			
Military Departments	1,400	1,642	1,585
Defense Agencies	891	634	846
Total Advanced Technology Development	2,291	2,276	2,431
TOTAL SCIENCE AND TECHNOLOGY	5,769	5,569	5,845
Strategic Defense Initiative	3,606	5,564	6,644

Note: A DoD budget review in process at printing time may alter the above figures.

II. MANAGEMENT ACTIONS

Within the S&T program there are management activities and initiatives important to the conduct of an effective program. They are important because often they are the vehicles by which goals are achieved. These topics stem from both Congress and the Administration and are significant aspects of S&T program formulation and management. This section discusses some of these activities.

A. Balanced Technology Initiative (BTI)

The Balanced Technology Initiative (BTI) is a technology development and demonstration program structured to accelerate progress in selected areas considered critical to conventional defense missions. Program efforts involving smart weapons technology are accelerating the development of fire-and-forget weapons that offer significant force-multiplier advantages, particularly for engagements at extended ranges. Work involving the collection of intelligence will enable more effective use of our combat forces by improving targeting capabilities and facilitating more efficient deployment of battlefield assets. Armor/anti-armor activities include development of affordable high-performance armor materials, advanced guns and projectiles, and new concepts, all intended to promote increased survivability and overall effectiveness of ground combat forces. Significant progress is also being made in the development of advanced mine concepts and mine detection techniques. Other BTI projects include work on high power microwaves, enhanced blast munitions, and technologies important to the development of advanced close air support aircraft.

The BTI is an important element of the DoD S&T program that facilitates the initiation of promising new work and accelerates the transition of technology into full-scale development. The BTI program is managed by the Office of the Director, Defense Research and Engineering, and the Director is the decision authority for initiating new projects. Specific projects are executed by the appropriate Service or Defense Agency, and multi-Service efforts are encouraged. OSD provides overall guidance and oversight to assure effective coordination with other conventional warfare activities.

B. <u>The University Research Initiative</u>

DoD initiated the University Research Initiative (URI) in FY 1986 to enhance university capabilities in research and in the education of scientists and engineers in fields of importance to national defense. Between FY 1986 and FY 1988, about 90 percent of URI funds supported multidisciplinary research. The remaining 10 percent of FY 1986-1988 URI funds supported "people programs," including graduate fellowships, young investigator awards, and scientific personnel exchanges.

DoD reduced URI's emphasis on multidisciplinary research in FY 1989 as a result of two provisions in the Defense Appropriation Act, 1989. In response to one provision, DoD allocated $5 million of FY 1989 URI funding for a new program of graduate fellowships in science and engineering. This program will increase the number of fellows funded by URI in the 1989-90 academic year from 260 to 355, about one-third of the estimated 1000 graduate students supported by URI.

In response to the second provision, DoD submitted to Congress a plan for broadening the geographical participation in the URI program. The Department currently is implementing the

plan by competing $5 million of FY 1989 URI funding for a new Research Initiation Program. This new thrust is designed to attract institutions that have capabilities to perform defense research, but may not have the breath of strengths necessary to assemble multidisciplinary teams. Proposals are being solicited specifically from institutions that have not been major recipients of DoD research and development funding in recent years, including historically black colleges and other minority institutions.

The DoD recently submitted to Congress a report, requested by the conference report accompanying the National Defense Act for Fiscal Year 1989, "for the eventual transition of the URI program from its current focus on multidisciplinary research to the broader focus of enhancing the nationwide quality of science and engineering graduate education balanced with multidisciplinary research." As the first phase of the transition, the Research Initiation Program will grow from about 5 percent of URI in FY 1989 to about 14 percent in FY 1991, if initial results so warrant.

In the second phase of the transition, investments will increase in "people programs" and university research instrumentation programs beginning in 1992 as the current multidisciplinary URI projects approach the end of their initial five year commitment. At the conclusion of the two phases, multidisciplinary research will have decreased from about 90 percent in FY 1986-1988 to about 60 percent in FY 1993-1994 with a corresponding increase in other infrastructure activities.

C. <u>Independent Research and Development (IR&D)</u>

IR&D continues to be an important component of the nation's total research and development program. In addition to "hedging"

DoD-sponsored research, company-selected, company-sponsored IR&D efforts provide DoD with a national pool of well-qualified contractors needed for future developments. The vitality of the program has been demonstrated in that almost all modern military systems have at least some IR&D roots with components already available because of prior IR&D funded developments.

The Department continues to seek ways to improve the IR&D process by removing impediments to its productivity. The removal of the IR&D cap and its replacement with a DoD target has allowed much-needed flexibility in managing the program. Further improvements are under consideration including initiation of a two-year cycle to reduce administrative burdens. As soon as details are worked out, it is planned to implement the two-year cycle. In addition, the use of electronic information processes to accelerate evaluations and other administrative actions is planned. The IR&D program is considered essential to provide competent, competitive contractors and innovative technology

D. Transferring Technology to Deployed Systems

Very little, if any, military benefit can be derived from technology achievements that remain in the laboratory. Therefore, enhancing the incorporation of new technology into our weapon systems is one of our principal goals to improve the acquisition system. Often the availability of technology is not consistent with windows of opportunity for application. In addition, demonstrated technology is not always readily producible, and current or projected warfighting doctrine does not always include integration of new concepts into the force structure. Effective technology transition requires close cooperation between the users, requirements and development communities in order to be successful.

The entire process of technology transition is as variable as technology itself. We are not so naive as to believe that we can resolve the entire problem with one grand solution. Rather, we view it as a continuing process in which substantial progress is being made. Our opportunities are enhanced because the larger portion of our research and development is performed under contracts and grants and also under the auspices of the IR&D community. Thus, many of the organizations that develop our technologies also produce our weapon systems, providing a relatively favorable climate for technology transfer. We will continue to accelerate the introduction of advanced technology into our weapon systems whenever it provides us an advantage in availability, affordability or performance.

E. Investment Strategy

Anticipated warfighting needs, recognized deficiencies and changing threat projections determine to a large extent the elements of the S&T program. It is necessary that the program be responsive throughout the full spectrum of conflict from low-intensity operations to global conflict.

We have recently strengthened our planning process. In formulating the S&T program, the Services and Defense Agencies together with OSD determine technology needs to provide future military capabilities. These capabilities are identified through guidance provided by the Secretary of Defense and the Joint Chiefs of Staff, as well as threat analyses and projections. Investment strategies are then developed that are coordinated across the Components to resolve differences, to assign lead responsibilities, to identify missing elements and to set priorities with respect to the goals established. It is our plan to have this process in place during the FY 1992-94 planning and budgeting cycle.

F. Critical Technologies

Public Law 100-456, The National Defense Authorization Act, FY 1989, requires the DoD to submit annually, and not later than March 15 of each year, a Critical Technologies Plan, to develop technologies most essential to ensure the long-term qualitative superiority of US weapon systems, with the first plan to be submitted in 1989. It should be noted that the planning process discussed above will provide, as a natural byproduct, a rapid update of the Critical Technologies Plan on an annual basis.

III. TECHNOLOGY PROGRAM

As indicated earlier, the DoD S&T program develops options for improved warfighting capabilities. The broad scope of these options not only requires that we pursue a multitude of technical disciplines, but also that the technology developed be used in multiple applications. We traditionally manage the program by technical discipline or area. However, in order to ensure a coordinated investment strategy and comprehensive program, we aggregate technology areas into clusters. The technology clusters are outlined in Table II.

The significance of a balanced S&T program cannot be overemphasized. An effective S&T program must be well-proportioned with regard to technology mix. For example, superior weapon systems demand superior simulators for crew training, and superior main battle tanks require superior river bridging capabilities. Also, sound environmental understanding and predictions are required to permit effective use of most systems. In addition, we must maintain activity in core technologies, such as materials and microelectronics, in order to cope with increasingly difficult military applications.

TABLE II

SCIENCE AND TECHNOLOGY PROGRAM

WEAPON CLUSTERS

- WEAPONS TECHNOLOGY
  - Tactical Missiles Guidance and Control Technology
  - Target Acquisition and Fire Control Technology
  - Torpedoes and Undersea Warfare Weaponry Technology
  - Gun Technology
  - Bombs and Clusters
  - Landmines, Landmine Countermeasures and Barriers
  - Directed Energy Weapons
- VEHICLE MOBILITY TECHNOLOGY
  - Aircraft Propulsion Technology
  - Missile and Space Vehicle Propulsion Technology
  - Aeronautical Vehicle Technology
  - Avionics and Vehicle Electronics
  - Land Mobility Technology
  - Ocean Vehicle Technology
- ELECTRONICS
  - Command/Control/Communications Technology
  - Search and Surveillance Technology
  - Electronic Warfare Technology
  - Electronic Device Technology
- ENVIRONMENTAL and LIFE SCIENCES
  - Environmental Sciences
  - Environmental Quality Research and Development
  - Training and Personnel System Technology
  - Medical and Life Sciences
  - Chemical and Biological Defense
- SUPPORT TECHNOLOGY
  - Logistics
  - Materials and Structures
- SOFTWARE AND COMPUTER TECHNOLOGY
  - Software Engineering
  - Machine Intelligence
  - Computer Systems Engineering

Because of the number and diversity of projects in the S&T program, only representative ongoing activities are described in the remainder of this section beginning with the underpinning for all technology, the Research program:

A. Research

In the short span of this century there have been remarkable scientific and technical advances that have profoundly altered military strategy and tactics. Examples include radio, radar, computers, antibiotics, nuclear weapons, jet engines, guided missiles, microelectronics, lasers, satellites and smart weapons. Few of these advances could have been foreseen. Similarly, it is unlikely that it will be possible to anticipate explicitly what equally revolutionary advances will occur in the next century. Nonetheless, DoD's research projects are designed to assure that this nation continues to be a source of fundamental scientific knowledge and has the basic understanding and awareness needed to apply new discoveries quickly and effectively.

A strong research program also ensures that the US will be adept at understanding and countering technological surprises should they occur elsewhere. From DoD's research program we expect discovery, understanding, visibility of scientific advances that occur outside the DoD, transition support, technical fixes and the production of scientists and engineers. These demands require coverage of the scientific and engineering disciplines both in breadth and depth.

Accordingly, DoD research programs include mathematics, computer sciences, chemistry, materials, electronics, geophysics, oceanography, biology and medicine. Examples of current activity in a few of these disciplines are as follows:

o Chemistry. Noteworthy progress has been made in propellants and explosives that promise greater range and more effective warheads for missiles.

o Electronics. The quest for ever-faster, smaller-size, lower-powered electronics continues. Examples where progress is rapid include adaptive antennas, fault-tolerant microelectronics systems, ultra-high-speed superconducting analog/digital converters, integrated optoelectric circuits and electronic devices with quantum-sized features.

o Atmospheric and Ionospheric Behavior. It is important for military systems to operate no matter what conditions are imposed on them by nature. Understanding and predicting the atmosphere and ionosphere are necessary if that goal is to be achieved. Examples where progress is taking place include remote sensing, satellite and radar meteorology, arctic weather, tropical cyclone motion and interaction of electromagnetic waves with the ionosphere.

o Cognitive and Neural Sciences. In the cognitive sciences there is movement toward seeking greater understanding of neurological structures and mechanisms as a basis for understanding cognitive phenomena. Also, collaborations are underway between computer scientists and electronics engineers. They are developing artificial neural networks that offer potential for enhancing the abilities of computers to learn, to recognize patterns and to synthesize speech.

B. Weapon Technology

The weapons technology program provides for across-the-board improvements in non-nuclear weapons. It addresses the development of technology for guided missiles, mines, torpedoes,

guns, ammunition, and directed energy weapons. Of particular importance is the development of technology for precision, autonomous, stand-off conventional weapons that will contribute toward the enhancement of deterrence and vast improvements in US warfighting capacity.

o Brilliant Weapons. These weapons operate autonomously and are capable of selectively identifying, engaging, disrupting, or destroying targets at considerable standoff distances in adverse environments. The technology is directed toward the development of target recognition methodologies and of multimode sensors (electro-optical, infrared, millimeter wave, etc.), combining both passive and active operating modes. The anticipated increases in military capability provide us the ability to:

- Attack several targets within a large target complex with weapons fired in a single pass.
- Maneuver defensively or engage another target immediately after a weapons launch.
- Increase survivability by launching weapons at long standoff distances prior to target lock-on.
- Attack targets effectively in adverse weather and in severe electronic warfare conditions.

o Electric Gun. Developments of electrothermal guns, railguns, coilguns and related power generation technologies promise substantial increases in performance for tactical systems by the turn of the century. Current efforts are directed toward the selection of an optimum concept by FY 1991. A vehicle-mounted, large-caliber electric gun demonstration is planned by FY 1995. The advantages of an electric gun include:

- Multiple applications including anti-armor, air defense and artillery.

- Increased lethality against ceramic and reactive armor at increased ranges.
- Reduced logistics burden because of smaller projectiles and the elimination of propellants.

o <u>Advanced Torpedoes.</u> The United States and the Soviet Union have been moving toward powerful submarine forces that are becoming increasingly difficult to detect and defend against. Developments underway include warheads, drag reduction techniques and guidance and control technology for the next generation of torpedoes. These torpedoes will be capable of operating over longer ranges with increased speed, reduced weight and with reduced acoustic signatures. These future torpedoes will:

- Embody target discrimination, aimpoint selection, and countercountermeasure capabilities.
- Exhibit enhanced probability of kill and reduced attrition against the advanced Soviet submarines.

o <u>Directed Energy Weapons.</u> The directed energy program is developing technology for high-energy laser, high-power microwave, and charged-particle-beam devices. Also, the program addresses hardening of our equipment against hostile directed-energy weapons. These weapons could have a major impact on warfighting doctrine because of their rapid targeting and multiple shot capabilities. Progress in directed energy weapons technology could provide the following capabilities:

- Practical antisatellite weapons.
- Protection of military systems from high-power microwave attack.
- Mobile laser weapons for tactical engagements.
- Robust electronic countermeasures using high-power microwaves.

- Hard target destruction with using charged-particle-beam weapons.

C. Vehicular Mobility Technology

This cluster includes land, sea and air vehicles and their related propulsion and electronics technologies. Because vehicle platforms represent the largest single investment category in the defense budget, our programs are focused not only on attaining increases in capability, but also on making future vehicles more reliable and affordable. Highlights of our vehicle technology program include:

o Integrated High Performance Turbine Engine Technology (IHPTET). Historically, propulsion system performance has had the single largest impact on aircraft combat capability as well as life-cycle cost. The IHPTET program is directed toward doubling propulsion system performance by 2005 through a three-phase plan that allows for maximum technology transition to nearer term new or upgraded systems. The specific goals are: a 100 percent increase in thrust/weight ratio and a 50 percent reduction in specific fuel consumption for turbofan/turbojet engines; a 100 percent increase in power/weight ratio and a 40 percent reduction in specific fuel consumption for turboshaft/turboprop engines; and, a 100 percent increase in thrust/airflow and a 40 percent reduction in specific fuel consumption for expendable engines. These goals are to be achieved while maintaining the same life goals as those for engines currently in development. In addition, a reduction in the number of parts will provide for better maintainability and reduced life-cycle costs. Illustrative capabilities provided by the accomplishment of these goals would be:

- An intercontinental range cruise missile of the ALCM size.

- A sustained Mach 3+ capability in an F-15 size aircraft.
- A 100 percent increase in the range/payload capability of a CH-47 size helicopter.
- A supersonic short-take-off-and-vertical-landing fighter of F-15 size with greater range/payload capability.

o <u>Combat Vehicles.</u> The size, weight, mobility, survivability and cost of land combat vehicles are quite sensitive to advances in basic vehicle technology such as high-density power packs and concepts that reduce turret and crew sizes. We are pursuing efforts to develop and demonstrate by 1993 technology that will substantially decrease under-armor volume requirements, vehicle signatures, and operating costs. Accomplishment of the following goals would provide, for example, a 55-ton tank that has greater firepower and is more survivable than the M1A1 (65 tons) and that costs substantially less to operate and support:
- Fifty percent reduction in power-package volume by means of a high density propulsion system based on either a gas turbine or a diesel engine.
- Fifty percent reduction in turret volume by eliminating the need for a man in the turret.
- Reduction of the space needs of the suspension system by means of hydropneumatic equipment.
- Ten percent reduction in track weight and a 40 percent increase in track life.
- Substantial reduction in visible, infrared, and acoustic signatures.

o <u>Avionics and Vehicle Electronics.</u> Current activities are directed toward technology for highly integrated and reliable avionics to permit maneuver and attack over varying combat environments. Technology projects include integrated

heads-up displays, auto-target recognition, nap-of-the-earth inertial navigation and major increases in avionics reliability. Successful achievement of these goals will permit:

- Conducting air operations under night or adverse weather conditions.
- Reduced crew workloads while improving situational awareness.
- Nap-of-the-earth navigation without detectable emissions.
- High reliability, multiple sortie missions without the need for frequent repairs.
- Coordinated movement and massing of firepower for ground combat vehicles.

o <u>Ocean Vehicles.</u> Ships and submarines typically have a payload fraction equal to 20-25 percent of their gross displacement. The remainder of the basic vehicle consists of the hull, propulsion system, and auxiliary equipment. Advances in the related technologies have a significant influence on the size, cost, and capability of ocean vehicles, and by virtue of the importance of ocean vehicles in the force structure, on force capability as well. Technologies are being developed to reduce auxiliary machinery weights, improve propulsion system performance, reduce hydrodynamic drag, reduce vehicle signatures and increase survivability. Specific milestones include:

- Thirty percent reduction in ship propulsion fuel consumption by 1995 through use of an intercooled, recuperated gas-turbine engine and electric drive.
- Thirty-five percent reduction in fuel consumption for ship-service power by 1995 through integral propulsion/ship-service power systems.
- Thirty percent structural weight reduction for both ships and submarines by 1992 through advanced materials development and structural design concepts.

- Twenty to thirty percent reduction in auxiliary machinery weight for both ships and submarines by 1992.
- Reduction of radar, infrared, and acoustic signatures by 1992.
- Reduction of hull and track weight and improved propulsion systems for amphibious vehicles by 1990.

Accomplishment of these goals would provide, for example: destroyer class ships with improved survivability and a 50 percent increase in range or a 20-25 percent reduction in displacement; greater survivability and combat payload in submarines; and amphibious assault craft that allow a 300 percent increase in stand-off range.

o <u>National Aero-Space Plane (NASP).</u> The purpose of the NASP program is to develop, and then demonstrate in an experimental flight vehicle, the technology required for military and civil vehicles capable of operating at sustained hypersonic speeds within the atmosphere and/or as space launch vehicles delivering payloads into orbit. The experimental flight vehicle is currently envisioned to be a horizontal take-off and landing, single-stage-to-orbit craft. If successful, the NASP program will be the basis for a new class of superior military aircraft and space transportation systems.

The NASP program is conducted jointly with NASA, with policy, guidance and broad programmatic direction provided by the NASP Steering Group. The NASP program is currently in the technology development phase. The experimental flight vehicle phase may begin in 1991 if technology development warrants. Current activity includes:

- Airframe configuration studies by three contractors.
- Engine concept development and preliminary ground testing by two contractors.

- Development of the required lightweight, high-strength, high-temperature materials by a consortium of five NASP contractors.
- Development of computational fluid dynamics codes and applications by NASA, the contractors and other research organizations.

Past investment in vehicle mobility technology has provided US forces with the world's most capable combat aircraft, quietest submarines, and most effective main battle tanks. Current programs in vehicular technology will insure that we maintain a decisive edge in future combat arenas.

D. Electronics Technology

Rapid and accurate collection and dissemination of information is essential to success on the battlefield and is a key factor when engaging numerically superior forces. Also, the ability to disrupt enemy communications and fire control systems can provide a decisive combat edge. Highlights of electronics activities include:

o Integrated Command/Control/Communications for Combined Forces. An important capability is the need to synchronize fighting units of combined forces with near-real-time interoperable C3 systems. Our lead in computers, communications and related technologies provides a strong base for developing a fully integrated near-real-time communications system. Goals include techniques that will link multiple battlefields, provide modularity, increase flexibility and improve operational decision aids. The development of these capabilities could provide:

- Automatic communication links regardless of distance.
- Assured reliability against hostile countermeasures.

- Low probability of intercept communications.
- Dispersion of force and command posts with potential reduction of the force structure.
- Decision support (artificial intelligence) assistance, to force commanders.

o <u>Surveillance Technology.</u> Longer range and over-the-horizon weapons require improved surveillance for both offensive and defensive capabilities. Advances in this technology will make significant improvements in the performance of platforms operating in land, air, space, air-ocean interface and subsurface environments. Developments will provide for;

- Improved capabilities in detection, classification and tracking a variety of threats in operating environments.
- Active and passive systems to counter the next generation of submarines, aircraft and other vehicles in adverse as well as benign environments.

o <u>Bistatic and Synthetic Aperture Radar.</u> Bistatic radars (separate transmitter and receiver locations) have greater ability to function in the face of higher density electronic countermeasures and anti-radiation missiles. Synthetic aperture radar, on a penetrating platform, will provide an all-weather means for automatically detecting, identifying and locating second echelon forces. Attainment of these goals will provide for:

- All-weather detection, tracking and classification of low-observable targets.
- Detection and classification of stationary targets possibly obscured by foliage.
- All-weather information on second echelon forces hidden from long-range, stand-off sensors.
- Reductions in sensor cost and weight.

o <u>Electronic Warfare.</u> Future battlefields will contain a very large number of complex electronic signals that span the frequency spectrum. US command, control, communications, and sensor systems must coexist with allied and hostile electromagnetic emitters, making management of electronic warfare an essential but extremely difficult aspect of combat. Electronic warfare goals include a 100 percent improvement in power output-to-system density, survivability concepts at affordable cost and the development of generic countermeasures that negate entire classes of threats without the need for detailed intelligence or specific design data on hostile emitters. Attainment of these goals will provide for:

- The ability to operate with a low probability of detection but with awareness of allied and opposing force locations.
- The performance of missions in dense electronic warfare environments with acceptable attrition.
- The disruption, exploitation, and destruction of critical C3 nodes and sensors, thereby denying hostile forces intelligence and coordination abilities.

o <u>Electron Device Technology.</u> Electron devices continue to achieve greater performance levels while, at the same time, providing for better reliability, smaller sizes and lower costs. We are continuing to make investments in the microelectronics, microwave/millimeter wave and electro-optical areas because electronic devices will continue to be critical elements in most future weapon systems. In addition, greater emphasis is being placed on manufacturing productivity improvements that will benefit both the defense and commercial communities. Achievement of our goals in this area will provide for:

- Advancements in integrated circuits, at 0.5 micrometer feature sizes, that will permit higher functional

complexity, greater speed, radiation hardness and reduced life-cycle costs.

- Development of 1 to 100 GHz transmitter, receiver and detector circuits for use in advanced radar, electronic countermeasures and communications equipment and brilliant weapons.

- Establishment of a production base for affordable infrared focal plane array sensors that will meet the burgeoning needs of space surveillance and tracking and tactical weapon targeting.

- Development of semiconductor manufacturing technologies that not only will help us meet military needs but also will be the basis for establishing world leadership in a technology important to industrial competitiveness.

E. Environmental and Life Sciences

This cluster addresses technologies that are critical to the successful operation of modern weapon systems and to the command decisions that often dictate the outcome of battles. Efforts are conducted in environmental sciences, training, personnel, medicine, life sciences and chemical/biological defense. Our current activities include:

o Target Area Environment Characterization and Prediction. Weather and obscurant conditions are significant factors in the effective use of otherwise perfectly operating "smart" weapons. Efforts are being pursued to develop the technology for combat weather determination and prediction, multi-spectral data sources and simplified weather depiction techniques. These aids will provide support and give battle commanders decision options at all command levels on land and at sea. Accomplishment of these objectives will provide for:

- Optimum use of combat resources.

- Increased operational effectiveness under adverse weather or obscurant conditions, including capabilities to distinguish dim targets in clutter situations.
- Increased survivability in a nuclear, chemical or biological environment.
- More effective use of environmental conditions as a factor in planning and executing military operations.
- Improved weather and terrain data integration for making tactical decisions.

o Space Environment and Hazards. Spacecraft systems and personnel experience hazards in the space environment because of interactions with energetic and charged particles. Spaceborne sensors are adversely affected by naturally occurring and man-made infrared and ultraviolet backgrounds. Efforts are underway to develop technology to provide hazardous condition warnings, solar forecasts and an automated spacecraft electric discharge control system. In addition, means are being developed to better define atmospheric/celestial background clutter for improved spaceborne target surveillance, detection and tracking. Accomplishment of these objectives will provide for:

- Increased survivability of advanced microelectronics in space systems.
- Automated defense against damage from spacecraft electrical charging.
- Reduced risk to manned operations in space.
- Improved space target detection with fewer false alarms.
- Improved detection for low-observable vehicles in the atmosphere.

o Ocean Environment Exploitation. The undersea world differs radically from the atmospheric environment. Dynamic conditions of the undersea world have a pronounced effect on the

ability of sensors and weapons to counter the threat posed by the latest generation of quite submarines. It is essential that our understanding of the undersea environment be increased to:

- Shorten the processing time for large acoustic systems.
- Improve the spatial resolution of acoustic systems.
- Better predict the rapid changes in the undersea conditions in order to optimize the effectiveness of all classes of sensors and weapons.

o <u>Combat Casualty Care.</u> Minimizing battlefield casualties is essential for sustaining combat operations. The best use of medical resources will enhance survival and return casualties to duty rapidly. Major payoffs expected from current activities include:

- A powdered universal blood substitute.
- Concentrated blood volume expanders for battlefield treatment of hemorrhagic shock.
- Improved treatment of combat burn injuries.
- Therapies to prevent major organ system failure after injury.
- Rapid diagnostic tests for detecting septic shock.
- Liquid dressings for improved treatment of combat wounds.
- A computer-based diagnostic and treatment system for use in isolated areas.
- Methods of adapting individuals to cold weather exposure prior to deployment.
- On-site production of oxygen and resuscitation fluids.

o <u>Integrated Life Cycle Design.</u> Weapon system design includes not only consideration of the hardware, but also the people (manpower, personnel, training, and safety--MPTS).

Current activities are directed at the development of computer based-interactive engineering design tools to integrate MPTS factors into weapon system design at the engineering work station. Realization of our goals in this area will provide for:

- Reduction in weapon field test failures with operational personnel.
- Increased sustainability of new weapon systems.
- MPTS availability and cost trade-offs during early phases of the acquisition cycle.

o <u>Chemical and Biological (CB) Defense</u>. The threat of potential adversaries using CB weapons is greater today than at any time in the past 50 years. Accordingly, we are pursuing the development of concepts, methods and materials for the detection, identification, decontamination of, and protection against known and future chemical and biological agents. In addition to more effective filters and clothing materials, more efficient microprocessor-based detectors, using spectrometry and biotechnology techniques, are being developed. The following payoffs are expected:

- Point sampling alarms to classify and measure concentrations of nerve, blister, toxin, and pathogen agents.
- Laser stand-off detectors with a total chemical-contamination reconnaissance capability.
- CB mass spectrometers to detect, identify, and determine concentrations of chemical and biological materials present in the ambient air as vapors, aerosols, or liquid droplets.
- Small economical CB monitors for shipboard spaces.
- Improved masks and collective protection systems.
- Improved chemical protective overgarment materials.

F. Support Technology

Support technologies are so pervasive that they are addressed in a separate cluster. Included herein are our efforts in materials and structures development (excluding electronic materials) and logistics technology. Logistics technologies cover weapon support including maintenance, diagnostics, and manufacturing processes. Our current efforts in these areas include:

o Materials and Structures. Materials and structures are enabling technologies that are fundamental to significant advancements in many mission areas. A new composite material provides the weight reduction and strength needed for a revolutionary cruise missile. A new adhesive permits development of space vehicle members that can withstand a rigorous environment and increase payload at the same time. And, an advanced material is the means by which a supersonic erosion resistant canopy is developed. The materials and structures program is concerned with structural components, thermal protection and functional materials. The program goals include:

- Development of protection against battlefield lasers for personnel, optical sensors, aircraft canopies and vehicle structures.

- Development of materials and structures for advanced turbine propulsion engines and hypersonic vehicle structures that will lead to a demonstration of an all-weather, highly-survivable, low-observable intercontinental cruise missile and weight-efficient, short-takeoff-and-landing aircraft.

o Diagnostics and Prognostics. Rapid diagnostics and timely prediction (prognostics) of component failures will increase availability of our weapons and become an effective

means for improving readiness and availability. Our goals are to develop:

- User-friendly electronic data bases to replace paper technical manuals.
- Computer-aided reasoning for rapid diagnostics and fault isolation.
- Embedded sensors signaling the need for maintenance before failure occurs.
- Self-repair by system reconfiguration based on in-flight diagnostics.

o <u>Maintenance Information System.</u> We are developing a computer-assisted approach to total weapon system maintenance. Technical data, training, diagnostics, management, scheduling and historical data bases will be linked together. A hand-held computer will provide flight line personnel with totally digitized technical orders and interface with on-board aircraft computers and large mainframe computers in the maintenance depots. We expect to demonstrate that integrated maintenance information systems can result in substantially reducing troubleshooting time and increasing maintenance accuracy.

G. <u>Software and Computer Technology</u>

The growing size, complexity and importance of computers in defense systems requires that we undertake both technical and management initiatives to improve our posture in this key cluster. The software and computer technology program is structured to provide increasing capabilities for emerging systems while at the same time reducing the cost and logistics burden associated with development and life-cycle maintenance of computer and software resources. Highlights of the computer and software technology program include:

o Software Engineering. Software engineering addresses the automated tools, methods and standards required for a disciplined approach to software development and maintenance throughout the life cycle of a system. Significant improvements in military capability will result from:

- Integrated software engineering environments that improve productivity and provide complete life-cycle software support.
- Standardized programming languages and inter-tool interfaces.
- Software reuse during weapon system development.
- Improved software intrusion protection and multiple levels of security procedures.

o Machine Intelligence. Advances in software and computer hardware make possible knowledge-based systems that could reduce the dependence on direct human involvement in many complex and dangerous situations. Potential applications include:

- Machine assistance in the human decision process.
- Increased use of robotic devices in both combat and other hazardous environments.
- More effective automated fault diagnosis and testing.

o Computer Systems Engineering. This technology includes work in systolic arrays, highly parallel systems, neural networks and optical processors. Also, the work involves advanced computer memories, display technologies, and interface and architecture standards. Benefits to be achieved from these programs include:

- Significant improvements in processing capabilities.
- Increased radiation hardness of computer systems.

- Increased survivability of command and control functions through reconfiguration of networks after disaster or combat damage.

IV. CONCLUSION

The S&T program over the past 40 years has gone through a number of major transitions. Immediately after World War II it was clear that technology had played a major role in shortening the conflict. It was natural and completely acceptable that the DoD (and also the Atomic Energy Commission which grew into the Department of Energy) should sponsor efforts in research, even when military applications might not have been obvious, particularly since there were few other federal agencies able to support research. Now the role of the federal government in sponsoring research, and some development, has greatly expanded and it is natural that the DoD by choice and Congressional direction should limit its research (and particularly its development) to potential military uses. This is the case, although DoD is cognizant of its responsibilities to encourage the application of its technology to non-military uses that will strengthen the nation's economic competitiveness and stature.

The DoD S&T program plays a modest but important role in the context of the total federal research and development program. Within federal support for research, the Department provides about 10 percent and 25 percent respectively for basic and applied research. Although the DoD Research, Development, Test and Evaluation appropriation is about 60 percent of total federal research and development obligations, the statistic is misleading because most of the program supports a full spectrum of developments to provide the tanks, aircraft, ships and other equipment needed by our forces.

The Department is committed to conducting a strong S&T program because a principal key to our military and economic strength is the pace by which we evolve and transition technologies to meet the needs of the country. It is our goal to ensure that the DoD S&T program is given special management attention to enhance that part of the national security effort that provides a foundation for the future.